REMARKS

1. Response to Restriction Requirement

In the Office action Applicants were invited to reintroduce claims 62 and 167. As a result, Applicants have re-introduced claim 62 by inclusion of new claim 227.

2. Amendments to the Claims

Applicants have amended the claims to ensure that the same comport with the provisions of 35 USC section 112, second paragraph. No amendments to the claims were necessitated by material information, prior art or otherwise.

3. Rejections based upon Amatucci et al.

In the Office action all claims were rejected over Amatucci et al. Applicants respectfully contend that the reference by Amatucci et al. is disqualified as prior art in view of the attached declarations [hereinafter referred to as declarations) of Byung J. Choi (See EXHIBIT A) and Sidlgata Sreenivasan (See EXHIBIT B). The attached declarations show the conception of the presently claimed invention before June 20, 2000, the effective date of Amatucci et al. followed by diligence in constructive reduction to practice of the invention by the filing of the present patent application and the provisional patent application from which the present patent application claims priority. Thus, the Applicants respectfully submit that the reference by Amatucci et al. does not qualify as prior art pursuant to 35 USC § 102. Therefore, Applicants respectfully contend that the pending claims define an

invention suitable for patent protection in view of Amatucci et al.

Applicants respectfully request examination in view of this amendment. A notice of allowance is earnestly solicited.

CERTIFICATE OF TRANSMISSION/MAILING
I hereby certify that this correspondence is being facsimile transmitted to the USPTO *or* deposited with the United States Postal Service with sufficient postage as first class mail, in an envelope addressed to the Commissioner for Patents

Signed: Katrina Prati

Typed Name: Katrina Prati

Dated: 4-27-05

Respectfully Submitted,

Kenneth C. Brooks

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Choi et al.
Appl. No.: 09/934,248 GPAU.: 6502
Filed: 08/21/2001 Examiner: Mathieu Vargot
Docket No.: PA19-09V07 Conf. No.: 6698
For: FLEXURE BASED MARCO MOTION TRANSLATION STAGE

DECLARATION OF BYUNG J. CHOI

I, BYUNG J. CHOI, declare as follow:

1. I am over the age of eighteen years and am a listed as a co-inventor in the above-identified patent application.

2. I make this statement in support of an Amendment, which I am informed of and believe will be filed herewith in the above-identified patent application.

3. Attached hereto as APPENDIX is the relevant portion of an Intellectual Property Disclosure showing conception, by myself along with my co-inventor, Sidlgata Sreenivasan, of a flexure based macro motion translation stage as claimed in claims 1, 31, 62, 167, 212, and 226 that occurred within the United States prior to June 20, 2000, and which was constructively reduced to practice by the filing of United States provisional patent application number 60/226,763 and the above-identified patent application with the United States patent and Trademark Office.

The undersigned being warned that willful false statements and the like are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001, and that such willful false statements and the like may jeopardize the validity of the application or document or any registration resulting therefrom, declares that all statements made of his/her own knowledge are true; and all statements made on information and belief are believed to be true.

DATE 4/26/05

BYUNG J. CHOI

EXHIBIT A

Intellectual Property Disclosure UTA# [redacted]

I Descriptive

1. Title of Intellectual Property:

"Flexure Based Macro Motion Translation Stages, Z-stage and X-Y Stages"

2. Brief Description: Is the invention a new process, composition of matter, a device, trade secret, technology, is it computer software, or one or more products? A new use for an improvement of an existing product or process?

2.1 Abstract

Flexures are widely used in precision machines since they offer frictionless, particle-free and low maintenance operation, and they provide extremely high resolution. Most flexure based stages posses sub *mm* range of motion. The present invention discloses designs of flexure-based translation stages that have a range of motion of more than 12" and 12"×12" X-Y stages where two such translation stages are used. It is believed that these stages can be a cost-effective solution for lithographic applications, particularly in vacuum. Further, for imprint lithography techniques, the presence of imprint forces makes this an attractive choice over air bearings.

2.2 Description

In general, X-Y stages are made of two components: actuation and load-carrying components. Lead screw assembly mechanisms have been widely used where the positioning accuracy is not such a significant factor. For high accuracy applications, ball screw assemblies are used for both the actuating and load-carrying components. Backlash and stiction problems are not completely eliminated which are the major drawbacks for the ball screw system. Further, the need for lubrication makes it undesirable for vacuum or particle-sensitive applications.

A commonly used high precision X-Y stage is a combination of friction-drive and air bearing mechanisms such as the one used for Ultratech Stepper 1500, 1700 series. However, two important problems hinder the air bearing X-Y stage to be implemented in more advanced semi-conductor manufacturing equipment, such as vacuum compatible equipment. Firstly, it is impractical to use air bearing inside a vacuum chamber. The second problem is the possibility of

APPENDIX

[redacted]

mechanical failure of the bearing and friction-driven mechanism. The driving mechanism must not only be maintained clean but also, if replacement is necessary, extensive effort and time are required.

Magnetically levitated stages (referred to as maglev, here) were introduced to solve all the problems discussed above. By controlling magnetic fields, a substrate can be accurately positioned or oriented. Through various experiments, positioning accuracy of maglev has been proven to be sufficient for most advanced equipment. Some of the maglev designs use classical bearings or air bearings to support the weight of the moving body while the magnetic actuators are used as actuation only (such as US Patent No. 5760500). Others use magnetic fields as both the actuation and load-carrying systems. In this case, due to the non-linearity of the magnetic fields, accurate control of maglev has been a challenging task for systems with high degrees of freedom. Only a few cases of practical implementations of maglev were published since its introduction to the lithography industry. The overall cost of a state-of-art maglev is expected to be much higher than the previous two designs.

The designs presented here are macro motion translation stage with flexure joints and X-Y stages made of these translation stages. The load-carrying component of this flexure-based X-Y stage is made of links and flexure pivots. A major advantage of flexure mechanisms is the absence of frictional contact. An interesting design of a robot for use in ultrahigh vacuum was presented in [redacted]. The flexible arm mechanism of the robot is made of series of flexure joints. Only a very small number of particles have been detected throughout their experiments.

Figure 1 shows flexure pivots whose motion ranges make them a potential choice for the new macro motion translation stages (U.S. Patent 3807027). The flexure joint of Figure 1 has a rotation range of up to -30° to 30°. Such a motion range is considerably superior as compared to other classical

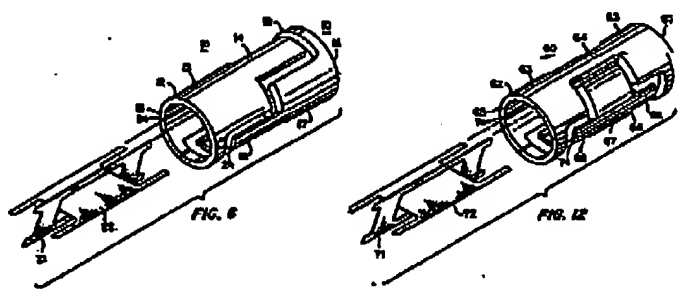


Figure 1. Flexure pivot [redacted]

[redacted]

[redacted]

flexure joints such as semi-circular notch or thin beam flexure pivots.

Figure 2 shows a flexure structure in its nominal configuration. This structure is known to have one degree-of-freedom in its nominal configuration and has been widely adapted for small motion applications. However, it can be shown that "moving body" has two degree-of-freedoms when the flexure mechanism is in off-nominal configurations (see Figure 3). Therefore, the undesirable degree-of-freedom must be eliminated from the stage for a large motion application.

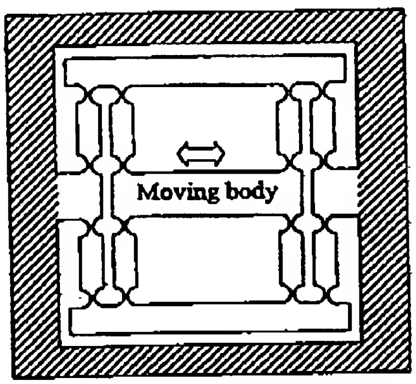


Figure 2 The double compound, notch type rectilinear spring

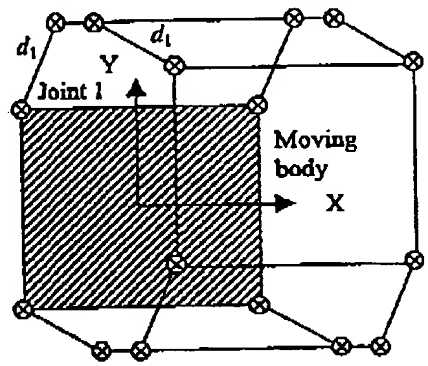


Figure 3 Two degree-of-freedom motion of Moving body

For a large motion application, in addition to the elimination of the undesirable degree-of-freedom, we can either i) make the flexure structure of Figure 2 large enough or ii) substitute the semi-circular notches of Figure 2 with flexure pivots. The first approach is impractical due to an unrealistically large size. The second approach is pursued here. The mechanism in Figure 3 is now optimized to lead to the smallest footprint for a 12" motion range. Figure 4 shows a schematic of portion of the basic linkage of Figure 3. Links 1 and 3 are of the same length. When "moving body" moves along X, all joints in Figure 4 rotate by the same absolute angle. It should be noted that the motion range is independent of the length of Link 2. Due to kinematic constraints, Link 2 remains parallel to the line connecting Joints 1 and 4. The range of motion, l_m, is given as,

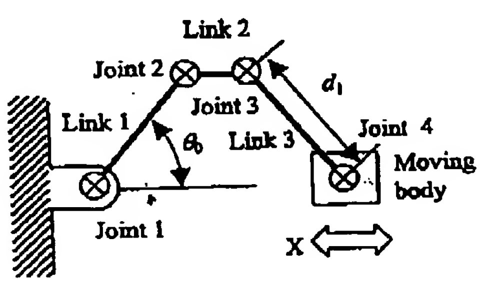


Figure 4 Linkage schematic

$$l_m = 2\, d_1\, [\cos(\theta_0 - \alpha_{max}/2) - \cos(\theta_0 + \alpha_{max}/2)]$$
$$= 4\, d_1 \sin(\theta_0) \sin(\alpha_{max}/2), \qquad (1)$$

[redacted]

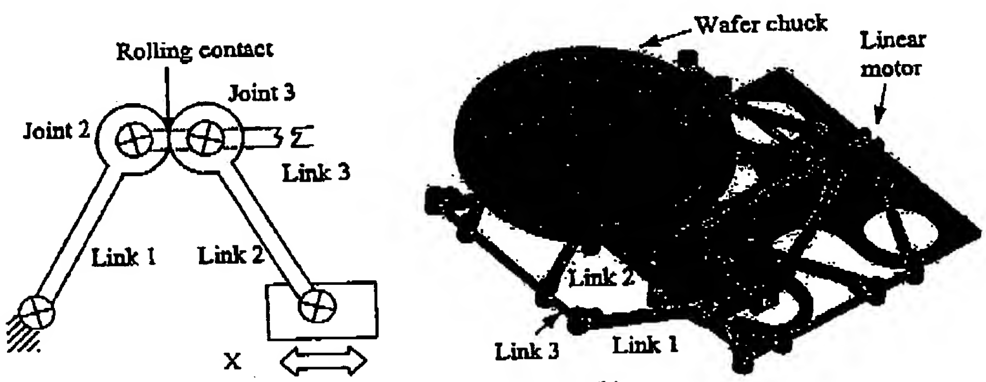
where, θ_0 is the angle of Joint 1 when all flexure joints are in their equilibrium conditions, α_{max} is the maximum rotation range of flexure pivots, and d_1 is the link length. As shown in Eqn. (1), for given d_1, the motion range is maximized when θ_0 = 90 Degree. Therefore, the link length is given as,

$$d_1 = l_m/[4\sin(\alpha_{max}/2)] \qquad (2)$$

The minimum link length, for a 12" motion range, is 6" (using α_{max} = 60°). Having completing the linkage size, two different designs that use two different approaches to constraint the linkage of Figure 4 to eliminate the undesirable degree of freedom presented next.

Stage Design 1

A kinematic study shows that if Joints 2 and 3 in Figure 5(a) rotate in opposite directions by the same angle, the stage generates a pure translational motion (along X in this case). By adding two identical cylindrical discs at flexure-made Joints 2 and 3, the resulting rolling contact can rotate Links 1 and 2 in opposite directions (see Figure 5 (a)). No additional joints or bearings are required since the cylindrical discs can be part of the links. The overall footprint and height are less than 20"×20" and 6" respectively (including a wafer chuck). Figure 5 (b) shows an assembled configuration (discs are not shown here). However, in order to prevent discs from slipping, an appropriate pre-load must be applied between the two discs. Compared to conventional stages where direct driven mechanisms or bearings are used, the contact surface here is relatively small, and should be relatively easy to maintain.



(a) (b)

Figure 5 Stage Design 1: Rolling contact at two neighboring flexure joints leads to the straight motion of Moving Body.

[redacted]

Stage Design 2

As mentioned earlier, an additional linkage system can be used to eliminate the undesirable motion (Y motion of Figure 3). Figure 6 shows a 3D drawing of the new X-Y stage design with additional linkages (the top stage is fully displaced). Additional linkages are the same one shown in Figure 4, however they are oriented orthogonal to the XY plane and move in the XZ plane. The overall footprint and height of a 12" motion range X-Y stage is estimated to be 29"×29" and 9.4" respectively (including a wafer chuck).

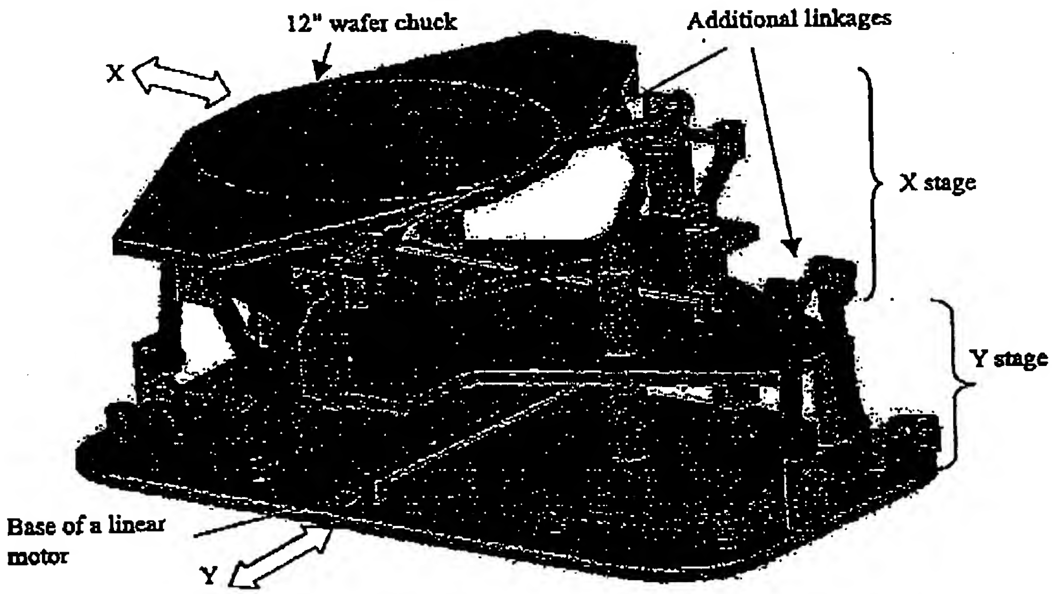


Figure 6 Stage Design 2: Each stage has only one degree-of-freedom. Undesirable motions are eliminated via "additional linkages"

As the actuation system, two linear servo motors are suggested, one for each axis (Figures 7 and 8). The absence of frictional contact, along with the fact that it readily produces actuation forces greater than 100 lbs make it suitable for the flexure-based X-Y stage. The weight of the stage is supported by the linkage structure. Therefore, actuation components only provide translational motion control in the X and Y directions. It is expected that using traditional laser interferometers as feedback, *nm* level positioning can be achieved. The actuator of the lower stage needs to be more powerful than that of the upper stage.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	Choi et al.		
Appl. No.:	09/934,248	GPAU.:	6502
Filed:	08/21/2001	Examiner:	Mathieu Vargot
Docket No.:	PA19-09V07	Conf. No.:	6698

For: FLEXURE BASED MARCO MOTION TRANSLATION STAGE

DECLARATION OF SIDLGATA SREENIVASAN

I, SIDLGATA SREENIVASAN, declare as follow:

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DATE April 29th, 2005

SIDLGATA SREENIVASAN

EXHIBIT B

[redacted]

Intellectual Property Disclosure UTA#[redacted]-[redacted]

I Descriptive

1. Title of Intellectual Property:

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APPENDIX

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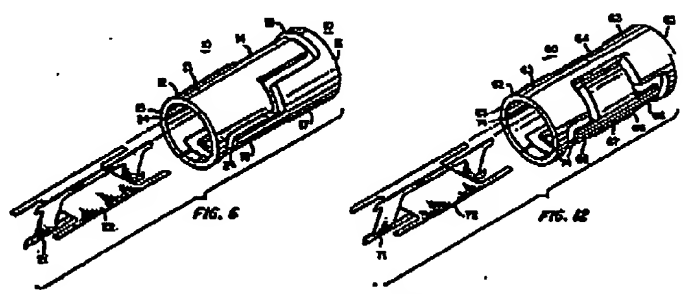

Figure 1. Flexure pivot [redacted]

[redacted]

[redacted]

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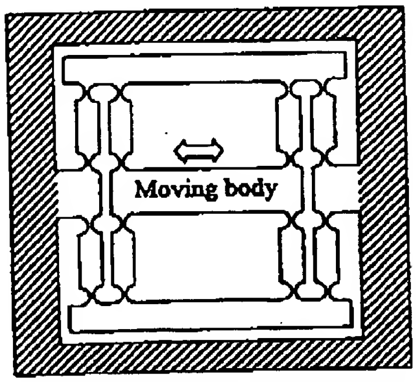
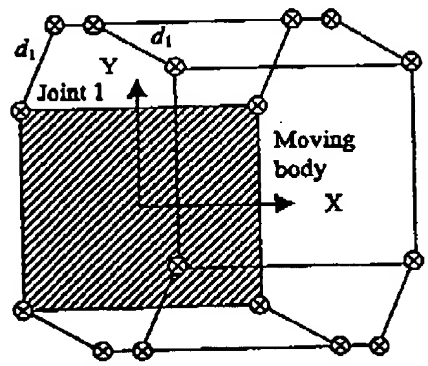


Figure 2 The double compound, notch type rectilinear spring



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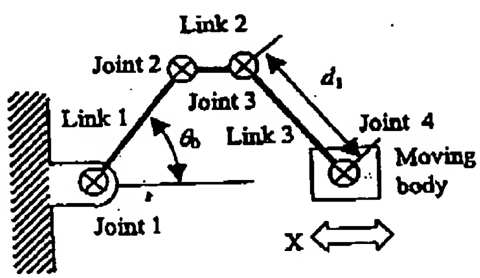

Figure 4 Linkage schematic

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where, θ_0 is the angle of Joint 1 when all flexure joints are in their equilibrium conditions, α_{max} is the maximum rotation range of flexure pivots, and d_1 is the link length. As shown in Eqn. (1), for given d_1, the motion range is maximized when θ_0 = 90 Degree. Therefore, the link length is given as,

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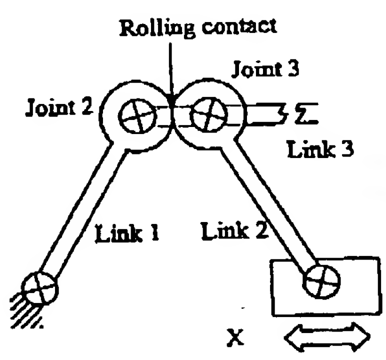

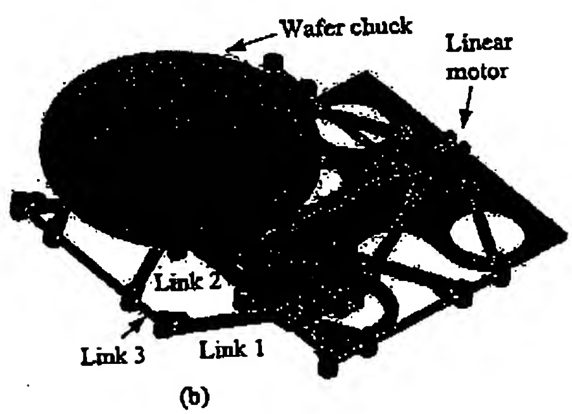

Figure 5 Stage Design 1: Rolling contact at two neighboring flexure joints leads to the straight motion of Moving Body.

[redacted]

Stage Design 2

As mentioned earlier, an additional linkage system can be used to eliminate the undesirable motion (Y motion of Figure 3). Figure 6 shows a 3D drawing of the new X-Y stage design with additional linkages (the top stage is fully displaced). Additional linkages are the same one shown in Figure 4, however they are oriented orthogonal to the XY plane and move in the XZ plane. The overall footprint and height of a 12" motion range X-Y stage is estimated to be 29"×29" and 9.4" respectively (including a wafer chuck).

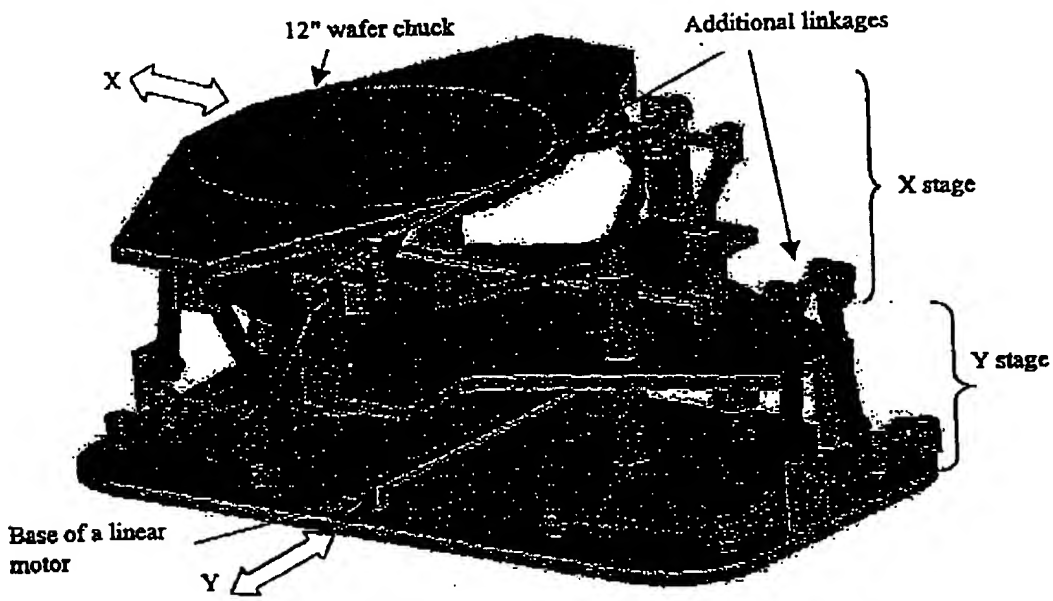

Figure 6 Stage Design 2: Each stage has only one degree-of-freedom. Undesirable motions are eliminated via "additional linkages"

As the actuation system, two linear servo motors are suggested, one for each axis (Figures 7 and 8). The absence of frictional contact, along with the fact that it readily produces actuation forces greater than 100 lbs make it suitable for the flexure-based X-Y stage. The weight of the stage is supported by the linkage structure. Therefore, actuation components only provide translational motion control in the X and Y directions. It is expected that using traditional laser interferometers as feedback, *nm* level positioning can be achieved. The actuator of the lower stage needs to be more powerful than that of the upper stage.